preferred flow profile of flow supporting surface **14*h***. As shown, a plurality of serially arranged flow sources **22*a–i*** provide a sheet flow of water over the flow supporting surface **14*h*** as indicated by streamlines **26*a–i***. The initial flow of water from the flow sources **22*a–i*** need not be completely horizontal to the ground nor perpendicular to flow surface **14*h***. Rather, the angle of incidence with the flow surface **14*h*** may vary in several directions, as desired, in order to create waves of various shapes and sizes. The angle of incidence of the sheet flow **26*a–i*** in the horizontal plane preferable ranges from about −45 degrees to about +45 degrees with respect to normal, as shown.

In the particular embodiment shown, two tunnel waves **36*a***, **36*b*** are formed, the main tunnel wave being formed by the streamlines **26*e*–26*i*** and the secondary tunnel wave being formed by the streamlines **26*a–c***. Starting from the lowermost flow source **22*a***, water under pressure is forced out of a nozzle or other flow forming aperture onto the flow supporting surface **14*h***. The flow supporting surface **14*h*** is angled and inclined such that the streamline **26*a*** rises up the incline and is then bent back upon itself forming a free falling tunnel wave **36*b***, as shown. Flow sources **22*b*–22*d*** inject corresponding water flows **26*b*–26*d***, which impact generally at the apex or "V" section of the flow supporting surface **14*h***. The velocity of the water flow at this point is preferably sufficient to overcome the potential energy at the uppermost ridge **18** of the flow surface at that point. Referring to FIG. **10**A, it can be seen that the ridge line **18** of the flow surface **14*h*** at the "V" point is relatively low so that the water easily flows over the flow surface **14*g*** at that point.

Beginning with flow sources **22*e***, a flow **26*e*** is projected upward onto the flow surface **14*h*** and is directed upward and to the right, such that the flow separates forming a dramatic tunnel wave **36*a***, as illustrated in FIG. **10**A. The remaining streamlines **26*f*–26*i*** also follow the same general path progressively flowing upward along the flow supporting surface **14*h*** and being directed across the walkway, as shown, to form a tunnel wave **36*a***. The radius of vertical curvature (ie. curvature about a vertical axis) of the flow supporting surface **14h** preferably decreases or gets tighter progressively toward the downstream end of the flow surface **14*h***. This allows each of the streamlines **26*e*–26*i*** to assume a generally converging funnel-type tunnel wave shape so as to provide a unique and inviting appearance. Alternatively, a constant horizontal or vertical curvature may also be employed or changing curvatures may be used, as desired, to form any number of desired symmetric or asymmetric wave shapes.

FIGS. **11**A and **11**B show an alternative embodiment of a tunnel wave awning water sculpture **10*i*** similar to that shown and described above in connection with FIGS. **10**A–C. In this embodiment, however, the flow surface **14*i*** has a simple horizontal concave curvature, curling past vertical back onto itself to form a partial cylinder. This embodiment may be particularly desirable in applications in which a highly uniform tunnel wave **36** is desired or where space constraints might otherwise prohibit the use of a more complex curving flow supporting surface such as shown in FIGS. **10**A–C.

FIGS. **12**A and **12**B show a further alternative embodiment of a tunnel wave awning water sculpture **10*j*** wherein the flow supporting surface **14*j*** extends substantially completely around the walkway **74** in order to form an enclosed cylindrical tunnel wave **36**. This embodiment is referred to as an "enclosed tunnel wave awning" because conforming water flow is caused to flow nearly 360° around the cylindrical flow supporting surface **14*j***. To achieve this effect, the velocity of the water flow should be at least sufficient to maintain conforming water flow along the inner surface of the flow supporting surface **14*i***.

Example 7

Dynamic Water Sculpture

Another desirable option for a water sculpture is to provide a dynamic component or effect such as a moving water swath **58**, as shown in the time-sequenced depictions in FIGS. **15**A–C. Moving water swath **58** has a sideways component or direction of travel (as indicated by arrow **60**), in addition to the previously described direction of flow **26**. Sideways component of motion **60** preferably moves at the rate of 1 to 5 meters per second. A moving aperture **56** can be formed from either a moving nozzle, moving weir, or sequentially opening an array of apertures (not shown). A variety of simulated wave forms can be readily accomplished by modifying the surface inclination of flow surface **14*k*** and/or the direction and velocity of water flow as previously described so as to form, for example, a simulated moving tunnel wave. The moving water swath **58** can also be caused to flow on any one of a number of other flow supporting surfaces, such as (by way of example only) those shown and described in connection with FIGS. **10–12**, above.

It should be understood that the preferred embodiments and examples shown and described herein are merely exemplary applications of a wave-shaped water sculpture having desirable features of the present invention. The scope of the present invention should not be construed as limited to any specific embodiment described herein. Rather, the invention may be embodied in a wide variety of other forms without departing from the spirit or essential characteristics as disclosed herein. Accordingly, it is intended that the scope of the present invention should be determined only by reference to the claims that follow.

What is claimed is:

1. ~~A water sculpture comprising:~~

Sub A

a flow surface adjacent a platform or walkway with at least a portion thereof having a generally inclined slope;

at least one source of water for providing a sheet flow of water onto said flow surface such that said sheet flow of water flows upwardly onto said inclined slope and substantially conforms to said flow surface; and

said flow surface having a shape adapted to simulate a desired wave form wherein at least a portion of said flow of water assumes an airborne trajectory over said walkway ~~to form a tunnel-like passageway.~~

2. The water sculpture of claim 1, wherein said flow surface has a shape adapted to simulate an undulating unbroken wave.

3. The water sculpture of claim 1, wherein said flow surface has a shape adapted to simulate a white water bore.

4. The water sculpture of claim 1, wherein said flow surface has a shape adapted to simulate a spilling wave.

5. The water sculpture of claim 1, wherein said flow surface has a shape adapted to simulate a tunnel wave.

6. The water sculpture of claim 5, wherein said tunnel wave forms an awning of a building.

7. The water sculpture of claim 1, wherein said flow surface is adapted to produce a plurality of simulated wave forms.

8. The water sculpture of claim 1, wherein said flow of water is supercritical over at least a portion of said flow surface.

9. The water sculpture ~~of claim 1, wherein said flow of water has a depth of at least~~ about 1 cm.

10. The water sculpture of claim 1, wherein said inclined slope is curved.

11. The water sculpture of claim 1, wherein said flow surface has at least a portion thereof having a generally downwardly inclined slope.

12. The water sculpture of claim 11, wherein said downwardly inclined slope and said inclined slope together form a curved half-pipe.

13. The water sculpture of claim 1, wherein said airborne trajectory is partially or fully directed by an outer enclosure or housing formed around said platform or walkway.

Sub A2

14. ~~An apparatus for forming a water sculpture, comprising:~~

a flow surface with at least a portion thereof having a generally inclined slope;

a platform or walkway adjacent said flow surface;

at least one flow source for providing a sheet flow of water onto said flow surface such that said sheet flow of water flows upwardly onto said inclined slope and substantially conforms to the contours thereof; and

said flow surface further comprising an upwardly rising section sized and configured so as to induce separation of said sheet flow, whereby at least a portion of said sheet flow of water assumes an airborne trajectory over said platform or walkway producing visual, aural and/ ~~or aesthetic appeal.~~

15. The apparatus of claim 14, wherein said flow surface is supported by a concrete structure.

16. The apparatus of claim 14, wherein said flow surface has an upward concavity along a longitudinal cross section generally parallel to the direction of said flow.

17. The apparatus of claim 14, wherein said flow surface comprises a longitudinal cross section having an upward concavity transitioning to an upward convexity.

18. The apparatus of claim 14, wherein said flow surface comprises a combination of straight, concave and convex surfaces relative to the direction of said water flow.

~~19. The apparatus of claim 14, wherein said flow of water on said flow surface has a relationship, characterized in terms of the Froude number, in a range of about 4 to 25.~~

20. The apparatus of claim 14, wherein said upwardly rising section comprises a wave forming structure obliquely positioned vertically and horizontally with respect to the direction of said flow of water on said flow surface, wherein said flow of water is directed upon said wave forming structure to create a spilling wave.

21. The apparatus of claim 14, wherein at least a portion of said flow of water has a velocity less than that needed to ascend over the top of said inclined slope of said flow surface, whereby a hydraulic jump is formed.

22. The apparatus of claim 14, wherein the kinetic energy of said flow of water is less than the potential energy of said flow at the top of said inclined slope of said flow surface.

23. The apparatus of claim 14, wherein the top of said inclined slope of said flow surface forms a ridge line.

24. The apparatus of claim 23, wherein a portion of said flow of water is provided at a higher velocity than another portion of said flow of water, wherein a cross-stream velocity gradient is formed, wherein said flow of water moving at said higher velocity flows over said ridge line, and wherein said flow of water moving at said lower velocity forms a hydraulic jump below said ridge line.

25. The apparatus of claim 24, wherein said ridge line has an increasing elevation from one side of said flow surface to another.

26. The apparatus of claim 14, wherein said inclined slope curls back past vertical whereby said flow of water on said inclined slope forms a tunnel wave.

27. A water awning comprising a tunnel wave water sculpture forming a sheet flow of water having an airborne trajectory over an adjacent walkway or entranceway to form a tunnel-like passageway.

28. The water awning of claim 27, wherein said water sculpture comprises a substantially cylindrical flow surface.

29. The water awning of claim 27, wherein said airborne trajectory is partially or fully directed by an outer enclosure or housing formed around said walkway or entranceway.

30. A walk-through water sculpture comprising:

a platform or walkway for allowing pedestrians or vehicles to traverse a predetermined distance;

a flow surface disposed adjacent said platform or walkway and having at least a portion thereof comprising a generally inclined slope;

at least one flow source for providing a flow of water onto said flow surface such that said flow of water flows upwardly onto said inclined slope substantially conforming to the contours thereof; and

said flow surface farther comprising an upwardly rising section sized and configured so as to induce separation of said flow of water on said upwardly rising section and thereby causing at least a portion of said flow of water to assume an airborne trajectory over said walkway.

31. The sculpture of claim 30, wherein said flow of water assumes an airborn trajectory simulating a tunnel wave.

32. The sculpture of claim 30, wherein said airborne trajectory is partially or fully directed by an outer enclosure or housing formed around said platform or walkway.

33. A water sculpture, comprising:

an inclined flow surface adjacent a platform or walkway;

one or more flow sources for providing a flow of water onto said flow surface, said flow conforming substantially to said flow surface; and

said flow surface further comprising a upwardly rising section sized and configured so as to induce separation of said flow of water on said upwardly rising section, whereby at least a portion of said flow of water assumes a trajectory that simulates a naturally occurring wave form projecting over said adjacent platform or walkway to form a tunnel-like passageway.

34. The water sculpture of claim 33, wherein said upward rising section comprises a tunnel wave generator for creating a desired tunnel wave flow shape.

35. The water sculpture of claim 33, herein at least two separate and independent flows are provided on said flow surface, each of said flows creating a desired flow shape or wave shape.

Sub D1

36. ~~The water sculpture of claim 33, wherein the velocity~~ of said flow is sufficient to cause said ~~flow to ascend~~ upward onto said flow surface ~~and~~ said upward rising section thereof, wherein by the force of gravity said flow is caused to return substantially upon itself in a downward arc to Ax a ~~curling or spilling wave.~~

37. The water sculpture of claim 33, wherein said flow surface is contoured and has a concave-up or semi-cylindrical curvatur.

38. The water sculpture of claim 33, herein said flow of water has a relatively uniform thickness.

39. The water sculpture of claim 33, wherein said trajectory is partially or fully directed by an outer enclosure or housing formed around said platform or walkway.

40. A water sculpture comprising:

a flow surface with at least a portion thereof having a generally inclined slope;

at least one source of water for providing a sheet flow of water onto said flow surface such that said sheet flow of water flows upwardly onto said inclined slope and substantially conforms to said flow surface;

said flow surface having a shape adapted to simulate a tunnel wave; and

a platform or walkway extending through said tunnel wave wherein said tunnel wave forms an awning over said platform or walkway.

41. A water awning comprising a tunnel wave water sculpture having a substantially cylindrical flow surface for forming a sheet flow of water over a walkway or entranceway.

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